INTERFACE CONTROL DOCUMENT

TA_SI_02_FL
Revision - 0

TELESCOPE ASSEMBLY / SCIENCE INSTRUMENT MOUNTING INTERFACE
– FINAL –

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY
(SOFIA)

JANUARY 2002

Approved for Final:

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FINAL ICD REVISIONS

Revisions to this document from the previous issue are denoted by vertical bars in the margin of each page.

REV	DATE	DESCRIPTION	APPROVAL
0	01/11/02	Initial NASA SPO Release of KT Final ICD TA_SI_02, Issue 5, Dated 20 December 2001. (SOF-ICD-KT-001)	/s/ J. Logan

TA_SI_02

Telescope Assembly / Science Instrument Mounting Interface

Assembly Identifier: TA

FINAL

SOF-ICD-KT-001

Issue: 5 FINAL

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Approved:	./s/ J. Davidson...................... (J. Davidson, USRA ICD POC)	Date:	1/30/02.........

Document Change Record

Iss./Rev.	Date	Description of Change	Pages Affected
Draft1	**23.06.97**	**First issue**	**All**
Draft2	**21.08.97**	**Update after ICWG meeting Waco 7/97:**	
		· RD4 from DCR 0025 to DCR 0025.R1 + preparation date	p. 2-1
		· added: "...avoid misorientation of SI....", "..Boltholes are through holes..", "...USRA provides .."	p. 4-1
		· Fig. 4-1 modified	p. 4-2
		· §4.1.3.6 "...Bolt torque...", §4.1.3.7 "...Bolt hole Diameter ..."	p.4-3
		· §4.1.4 completly reworked	p. 4-4
		· New Chapter 4.1.7 "Orientation Marker" + Fig. 4-3	p. 4-5
		· §4.2.3 120 kg / flight changed to 35 kg/flight	p.4-6
		· figure 4-3 correction of c.g. range diameter from 500mm to 1000mm	p. 4-7
		· § 4.3.3 ".. U=1870 mm ..."	p. 4-9:
		· §4.4 added: "..optical window assembly is provided by USRA...", §4.4.1 added: "... "..relevant for the interface..", "... thus on the side of ...", deleted:"..alternative pressure coupler interface." in fig. 4-5.	p. 4-11
		· deleted: §4.4.3, §4.4.4, §4.4.5, §4.4.6	p. 4-12
		· added: Fig. 4-6: "Principle of Airflow"	p. 4-14
		· §4.7 new text	p. 4-16
		· added: "..The here given volume..." "...The forward end...",	p. 4-17
Draft3	**10/10/97**	**UPDATE AFTER ICWG TELECON, 24.09.97:**	
		· TBDs and TBC have been assigned to a responsible	All
		· RD5 added (Flange Assembly Design Definition)	p. 2-1
		· §4.1: "..However for small instruments ..." replaced by "...However for some instruments...", added: "If the Optical Window Assembly is..."	p. 4-1
		· §4.1.5 Fig 4-1: "...example..." added	p. 4-5
		· deleted: "If the optical window is not installed", §4.3.6: "The O-Ring is provided by USRA"	p 4-12

Iss./Rev.	Date	Description of Change	Pages Affected
		· Figure 4-5: "preliminary concept of .." added	p. 4-13
		· § 4.4 reworked according to USRA inputs	p. 4-13 /4-14
		· § 4.6 reworked according to USRA inputs	p 4-17
Draft 3A	**5.2.98**	**Changed Format of Document Approval Sheet**	**i**
01/-	**27.05.98**	**BASELINE**	**Complete Revision**
		· Implementation of interface relevant data due to augmentations to FA design	
		· Implementation of Comments J. Davidson, e-mail 10.3.98, J. Fitch letter received 26.3.98	
		· Implementation of inputs e-mail Erickson, Casey 19.1.98	
		· Implementation of inputs e-mail Erickson, Davidson 28.12.98	
		· Implementation of comments IWG Meeting Dec. 97 Gustavsburg	
1/A	**15.7.98**	**Implementation of comments J. Davidson recieved 20.5.98 and 18.6.98 and ICWG meeting Munich 29.01.98**	
		· §1: Add "[worst case loading and] vibration spectrum"	
		· Fig 3.1: coordinate system, origin and distance to IMF fwd surface included	
		· § 4.1 Para 3 revised "The SI Flange and the IMF ...."	
		· § 4,1 Para 4 revised "The SI will be fixed......nutplates..."	
		· § 4,1 Para 5 revised "For standard operation the ..."	
		· § 4,1 Para 6 revised "To provide ..4 dowel pins ...."	
		· § 4.1 Para 8 changed	
		· § 4,1 Para 11 new "The IMF is equipped with locations for jack screws...."	
		· Figure 4-1: changes implemented	
		· Figure 4-1b: new figure	
		· § 4.1.3.2 revised	
		· § 4.1.3.3, .6, .7 need date implemented	
		· § 4.1.3.8 Changed hole diameter	

Iss./Rev.	Date	Description of Change	Pages Affected
		· New § 4.1.3.9 Nut Plates · Figure 4-2 revised · §4.1.2: complete revision · New Section §4.1.8 INF Material · §4.2.3 Revised according to DCR 0025 R2 · Figure 4-5 implemented · §4.3.5 ".. to be supplied by USRA" and need date · §4.3.6 Change O-Ring max. dia. from 260 to 240 · §4.4.6 New: Limit Loads for Pressure Coupler / Pressure Window Fixture · §4.5.3 NPT Threads instead of straight tubes inside Tub for exhaust / pumpout line connection to pressure coupler. · § 4.8 "Insulation removeable" · § 4.11 "Access port is ...pressure boundary...." · New §4.7.3 Airflow through Exhaust lines · New 4.7.4 Operation and Environment · §4.10.2 : clarification of limit and ultimate loads	
02/-	**12.05.99**	**Updates from:** - E-mail N. Kunz, NASA 26.3.99 - E-mail J. Davidson, USRA 22.3.99 - E-mail Davidson, USRA 12.3.99 - fax C. Wiltsee, NASA 24.2.99 - E-mail J. McCoury, USRA, 30.10.98 - E-mail J. Davidson, USRA 09.08.98 - Letter E. Ericson, NASA, 07.08.98 - E-mail J. Davidson, USRA 04.08.98	**All**
03/-	**March 2000**	**Updates from:** NASA comments / e-mail T. Brown 21.05.99 - e-mail J. Davidson 26.08.99 - e-mail J. Davidson 21.12.99	**--**

Iss./Rev.	Date	Description of Change	Pages Affected
		- e-mail J. Davidson 28.01.2000 - e-mail J. Davidson 02.02.2000 - e-mail R. Melugin 22.02.2000 <u>revised sections:</u> 1; 2.2; 4.1; 4.1.3; 4.1.3.3; 4.1.3.6; 4.1.4; 4.1.4.3; 4.1.9; 4.2.3; 4.3.2; 4.3.5; 4.3.6; 4.3.7; 4.3.8; 4.4.2; 4.4.6; 4.5.3; 4.5.4; 4.5.5; 4.6.5; 4.6.6; 4.7.1; 4.7.1.1; 4.7.1.2; 4.7.1.3; 4.7.2; 4.7.3; 4.7.4; 4.9.1; 4.9.2; 4.10; 4.10.1; 4.10.3; 4.11; 4.14; 4.15	
04/-	**December 2000**	**Updates from:** - NASA SPO comment Sheet dated 2/1/00 to ICD-KT-001, iss. 3, 3/22/00 - USRA Comments by J. Davidson dated 28.3.00 (e-mail 29.03.00) - Telecon USRA, MG, KT 18.05.00 - e-mail J. Davidson 09.09.00 - DCR 058.R2 - DCR 148 - Change of Pressure Coupler Bolthole Circle from 274mm to 275 mm - Seal-off fitting and Vacuum Locks as previously described in section 4.5.3 are no longer features of the FA/INF. <u>revised sections:</u> §2.2; §3 (figure 3-2); §4.1 (figure 4-1; 4-1b); §4.1.5; §4.2; §4.2.1; §4.2.2; §4.2.3; §4.3.2; §4.3.5.1; §4.3.5.2; §4.3.5.3; §4.3.5.4; §4.4.1 (figure 4-7a); §4.4.2; §4.5.3; §4.5.5; §4.7.1.1; §4.8; §4.9.1; §4.11	
05/-	**December 2001**	**- Final Version -** Updates from: - e-mail, J. Davidson dated 20.11.01 "...delete grade assignments from NAS Bolts..." - e-mail, P. DeLeon, dated 16.10.01 "... ICD required Documents List..." - e-mail, J. Davidson dated 01.10.01 "... add SRM and QA sections..."	

Iss./Rev.	Date	Description of Change	Pages Affected
		"...add actual measured accuracies of the dowel pins..." - e-mail J. Davidson / T. Kaluza, dated: 07.02.01: "...reference TA_SI_04 instead TA_SI_05..." - USRA Comments on TA_SI_02 Iss. 04 by J. Davidson, dated 06.02. 2001 - NASA Comments by A. Dinger and others, received 22.01.01 - DLR Comments by H. Witte dated: 10.01.01 Additional Changes due to comments by on the review version dated 29.11.01: - DLR, H. Witte, e-mail dated 5.12.01 - NASA, SPO, C. Wiltsee, e-mail dated 11.12.01 - USRA, J. Davidson, e-mail dated 14.12.01 revised sections: §2.1: AD01 changed to actual rev. 4, AD04 and AD05 added; §2.2:RD9 changed to TA EMC Control plan, RD21 to 24 added; responsible parties changed for RD2 and RD3; RD11 drawing number corrected §3 "BS" changed to "BSA"; §4.1: changed wording; "RD5" deleted; "nutplate design TBD by USRA" deleted; other minor changes in wording.; Figure 4-1: "Deep 30 mm" for hardpoints deleted; §4.1.3 "washers" added; §4.1.3.2: minor changes in wording, "grade 8" deleted; §4.1.3.3 TBD more precisely clarified; §4.1.3.6 "grade 8" deleted, torque limit defined; §4.1.3.7 changed title to "Bolt Data"; changed wording; "grade 8" deleted; §4.1.4: changed wording to reflect actual determined position accuracy of dowel pins after manufacturing; §4.1.5: "0.500" changed to "1/2"; §4.1.6.1/.4.1.6.3/4.1.7: English dimensions added; §4.1.8 "arrow shape" of marker deleted, clarified wording; §4.1.9 actual material is 1.4571, therefore 1.4546.9 deleted; §4.2.1 reference to wrong figure numbers deleted; §4.3 pressure coupler now to be provide by SI developer if required; §4.3.6.1/4.3.6.2: English dimensions added; §4.3.2: minor changes in wording; §4.3.5: inserts and tooling no longer required from USRA because manufacturing is accomplished; §4.4: reference to RD24 added; §4.4.6 note added that	

Iss./Rev.	Date	Description of Change	Pages Affected
		remaining info on TBD is not required by TA-C; §4.5: references to other ICDs added; §4.5.1/4.5.2: original wording replaced by references to other ICDs; §4.5.3: English dimension added; §4.5.4 changed wording and references to other ICDs added. §4.5.5/4.6 reference to other ICDs added; §4.6.1/4.6.2: original wording replaced by reference to other ICDs; 4.6.5 reference to other ICD added; 4.6.6 deleted; §4.8: English dimensions added; §4.10 English dimensions added; "0.500" changed to "1/2", depth added; inserts and tooling no longer required from USRA because manufacturing is accomplished; §4.10.1 "DCR0012.R2" changed to "DCR0012.R5 (AD5)"; §4.10.3: English dimensions added; §4.10.13: "TA_SI_05" changed to "TA_SI_04 (RD23)"; §4.11 bolt pattern and O-ring information added for the accessport; §4.14: "TBD" replaced by "to be measured during System AITV"; §4.15: English dimensions added; §4.16: "A USRA provided manufacturing tool ....." deleted; New SRM & QA Sections added (§5, §5.1, §5.2, and §5.3)	

CONTENTS:

ACRONYMS

AD	Applicable Document
aft	afterwards
BSA	Balancing Subassembly
c.g.	Center of Gravity
XEL	Cross Elevation
cfm	Cubic feet per minute
DCR	Document Change Request
DIN	Deutsche Industrie Norm (German Industrial Standard)
EL	Elevation
FA	Flange Assembly
FAA	Federal Aviation Administration
FPI	Focal Plane Imager
fwd	Forward
GVPP	Gate Valve Pressure Plate
HW	Hardware
I/F	Interface
ICD	Interface Control Document
IMF	Instrument Mounting Flange
INF	Instrument Flange
IR	Infra Red
LOS	Line of Sight
NPT	National Pipe Taper (American Standard Pipe Thread)
NT	Nasmyth Tube
PI	Principal Investigator
PWS	Pressure Window Subassembly
RD	Reference Document
SI	Science Instrument
TA	Telescope Assembly

TBC	To be Confirmed
TBD	To be Determined
U; V; W	Coordinates of the TA Coordinate System
VIS	Vibration Isolation System
Wt	Weight

1 Scope and Interface Contents

This document is to describe, define and control the SOFIA Telescope Assembly / Science Instrument Mounting Interface. This interface is led and documented by the TA Consortium member Kayser-Threde GmbH (KT).

The interface has the number TA_SI_02 and comprises:

- The mounting interface between SI and telescope instrument flange
- The mass and c.g. properties of the SI
- The pressure coupler interface
- The interface for the optical IR window
- The exhaust tube interface
- The vacuum lines interface
- Heat dissipation requirements and interface temperature limits
- The free volume aft of the SI flange
- Worst case loading and vibration spectrum imparted to the SI by the TA

2 Documents

2.1 Applicable Documents

AD1: SOFIA TA Development Statement of Work
SOW (DLR); REV. 4, 26.11.01

AD2: SOFIA TA Requirements
SOF-1011 (NASA); Rev. 6, May 1996

AD3: SOFIA Interface Requirements
SOF-1030 (NASA); Rev. 3, March 1996

AD4: DCR 0015.R2 Pressure Window Assembly
(NASA)

AD5: DCR 0012.R5 Clarify Loads Environment
(NASA)

2.2 Reference Documents

RD1: SOFIA Interface Reference Document
PD-2003 (NASA);

RD2: GLOBAL_01 Master Interface Control Document List
GLOBAL_01 (NASA)

RD3: GLOBAL_05 SOFIA Coordinate Systems
GLOBAL_05 (USRA/RAIS)

RD4: DCR Max. Change of SI Wt During Flight
SOF-DCR-0025.R2 (NASA)

RD5: deleted

RD6: Flange Assembly Description

SOF-SPE-KT-4000.0.02

RD7: Flange Assembly Drawing (KT Part)

SOF-DWG-KT-4000.0.00

RD8: Flange Assembly (with FPI)

SOF-DWG-MG-4000.0.01

RD9: TA EMC Control Plan

SOF-PLA-KT-6000.0.01

RD10: Minutes of meeting MPE Garching 29.06.98

RD11: Flange ICD (KT part)

SOF-DWG-KT-4000.0.01

RD12: Design Loads (for Stress Analysis)

SOF-TAN-MG-0000.0.04

RD13: TA SI Flange Dowel Pin Analysis

30.10.98, J. McCoury

RD14: Military Standard MS 21209, Rev. E, 21.02.98

Insert, Screw Thread, Course and Fine, Screw Locking, Helical Coil, C RES

RD15: USRA Experiments Handbook

Document OP03

RD16: German Industrial Standard DIN ISO 2768

RD17: TA EMC Control Plan

SOF-PLA-KT-6000.0.01

RD18: Science Instrument Airworthiness and Certification Procedures Manual, SOFIA Experimenters Handbook Chapter Three

USRA-DAL-1083-00 Rev: A

RD19: DCR148 SI cg & Mass Change Accomodation
(NASA)

RD20: DCR0058.R2 Telescope Balance
(NASA)

RD21: TA_SI_01 TA CLA to SI Cable Interface
SOF-ICD-MG-062

RD22: TA_AS_03 Aircraft System to TA CLA Interface
SOF-ICD-MG-059

RD23: TA_AS_04 Aircraft System / TA Optical and Non-Optical Installation and Removal Requirements

RD24: TA_AS_11 TA / Aircraft System Exhaust Tube and Vacuum Lines Interface

3 Interface Configuration

An overview of the TA with the mounted SI is given in figure 3-1. The Flange Assembly is shown in figure 3-2. A cross section of the FA (without BSA) is depicted in figure 3-3.

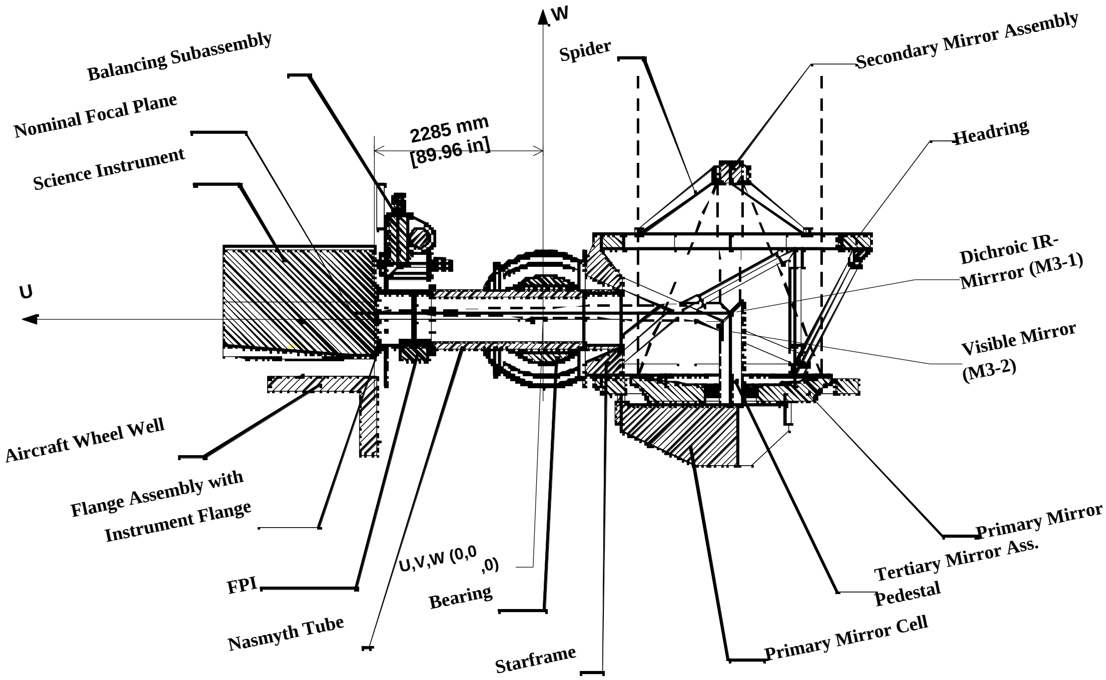


Figure 3-1: Mechanical TA System Configuration with Mounted SI

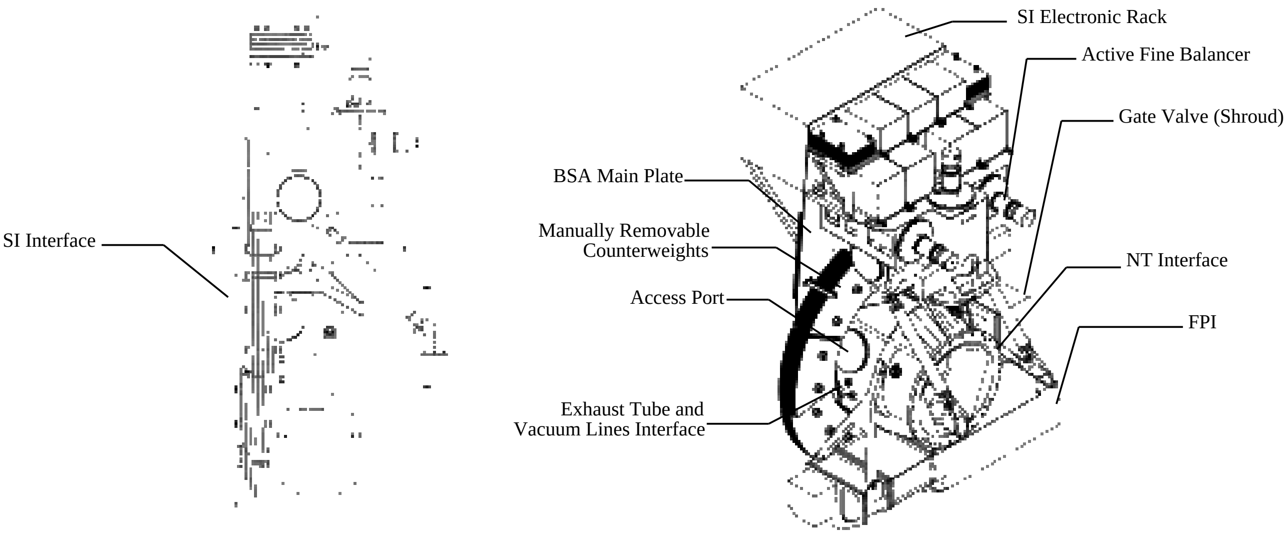


Figure 3-2: Schematic Sketch of the Flange Assembly (shown w/o Cable Load Alleviator)

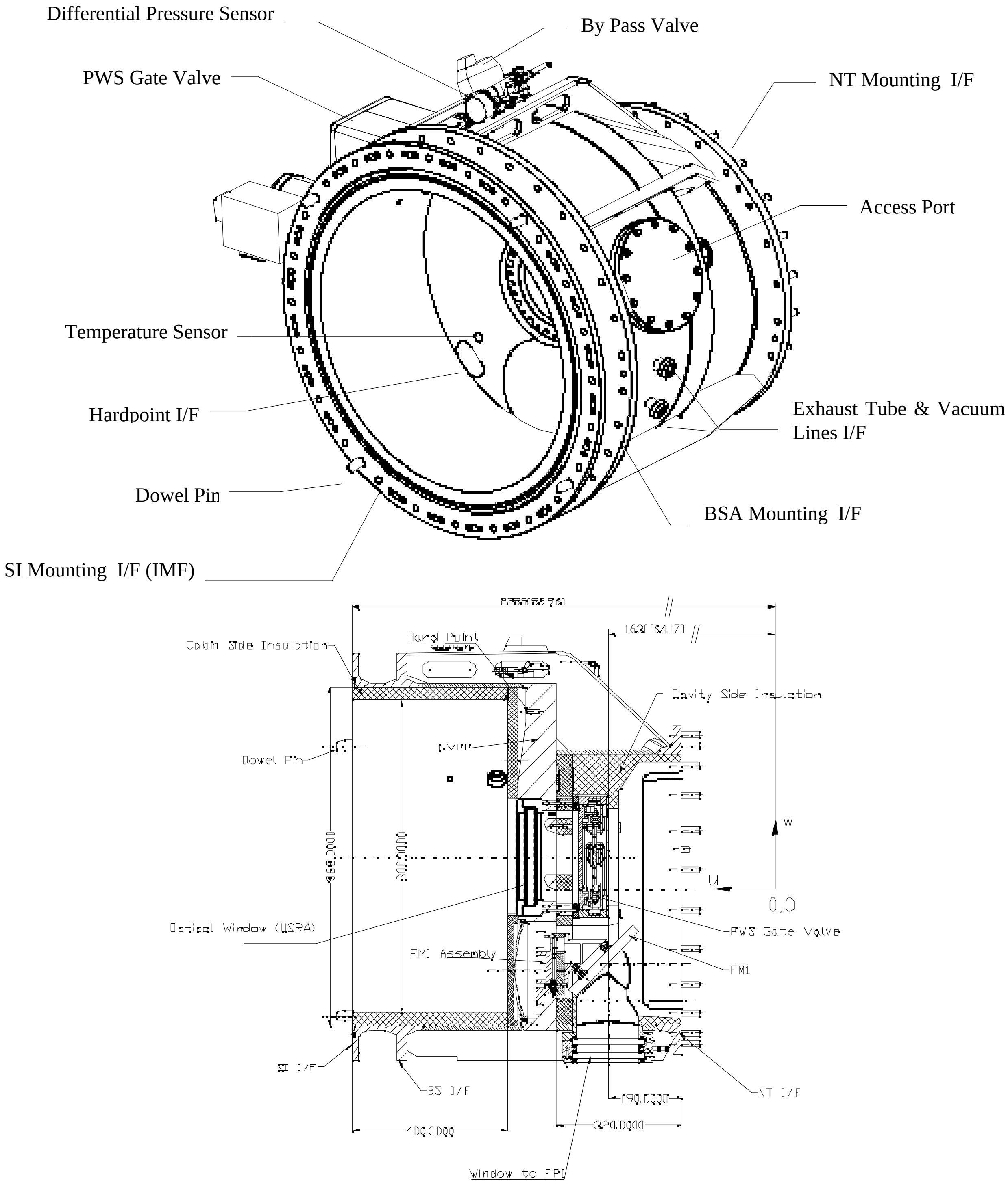


Figure 3-3: 3D View and Cross Section of INF and PWS without Balancing Subassembly

4 Interface Description

Note: All applicable dimensions within this document can be given either in metrical units or in Anglo-American units. The respective converted value is given in brackets for information only.

4.1 Mounting Interface between SI and Telescope Instrument Flange

The Instrument Flange (INF, HW No. 4100) is a Subassembly of the Flange Assembly (FA, HW No. 4000) which is part of the Telescope Assembly (TA).

The part of the INF to which the Science Instrument will be mounted shall be called herein IMF (Instrument Mounting Flange). The IMF is located at the fwd end of the INF.

The part of the Science Instrument which will be mounted to the IMF on the TA is called the SI Flange.

Refer also to RD6 about configuration, notations etc.

The SI Flange and the IMF are centered on the IR beam. Structural dimensioning of IMF and associated fasteners / pins assumes a 600 kg SI on a 41 inch diameter SI Flange, fastened with all 20 Screws (through holes and shear pin configuration).

The SI will be fixed on the IMF by bolts and nuts (20 each). Nuts can be optionally secured with nut plates. The bolts, located on a circle, are equally spaced in angular direction. Bolt holes in both flanges are through holes. Nutplates will be on the aft side of the IMF. USRA provides and installs bolts, nuts, and nut plates. The space available between the aft surface of the IMF plate and the fwd surface of the BSA Base Plate is shown in figure 4-1b. An additional hole pattern with 20 through holes is given for SI installations which do not use the nutplates (refer to figure 4-1).

For standard operation the FA provides the following vacuum sealing possibilities:

1. SI to IMF (and thus INF)
2. SI (via pressure coupler) to Gate Valve,
3. Window to Gate Valve. If the Optical Window Assembly is installed, it will form in some configurations the pressure seal to the cavity (refer to section 4.4).

The IMF is equipped with 4 dowel pins, each placed on the flanges bolt circle, 90 degrees apart. To provide accurate positioning of the SI or alignment tools to the TA, 2 (opposite) dowel pins on the IMF shall be used. Since the bolts are through holes, one of the pins will be used for positioning and for shear, the other only for angular positioning of the SI. The front view of the INF (IMF) is shown in figure 4-1 (and large scale in the Appendix).

The IMF and the SI Flange will have a marking on the circumference of their flange rings, which shall serve as zero point orientation for all SI flange installations.

There are additional hard points for mounting of SI hardware inside of the INF Tub (refer to section 4-10 for details).

The IMF is equipped with 4 jack screws to facilitate SI removal from the IMF. The jack screw locations are evenly distributed on the IMF bolt circle.

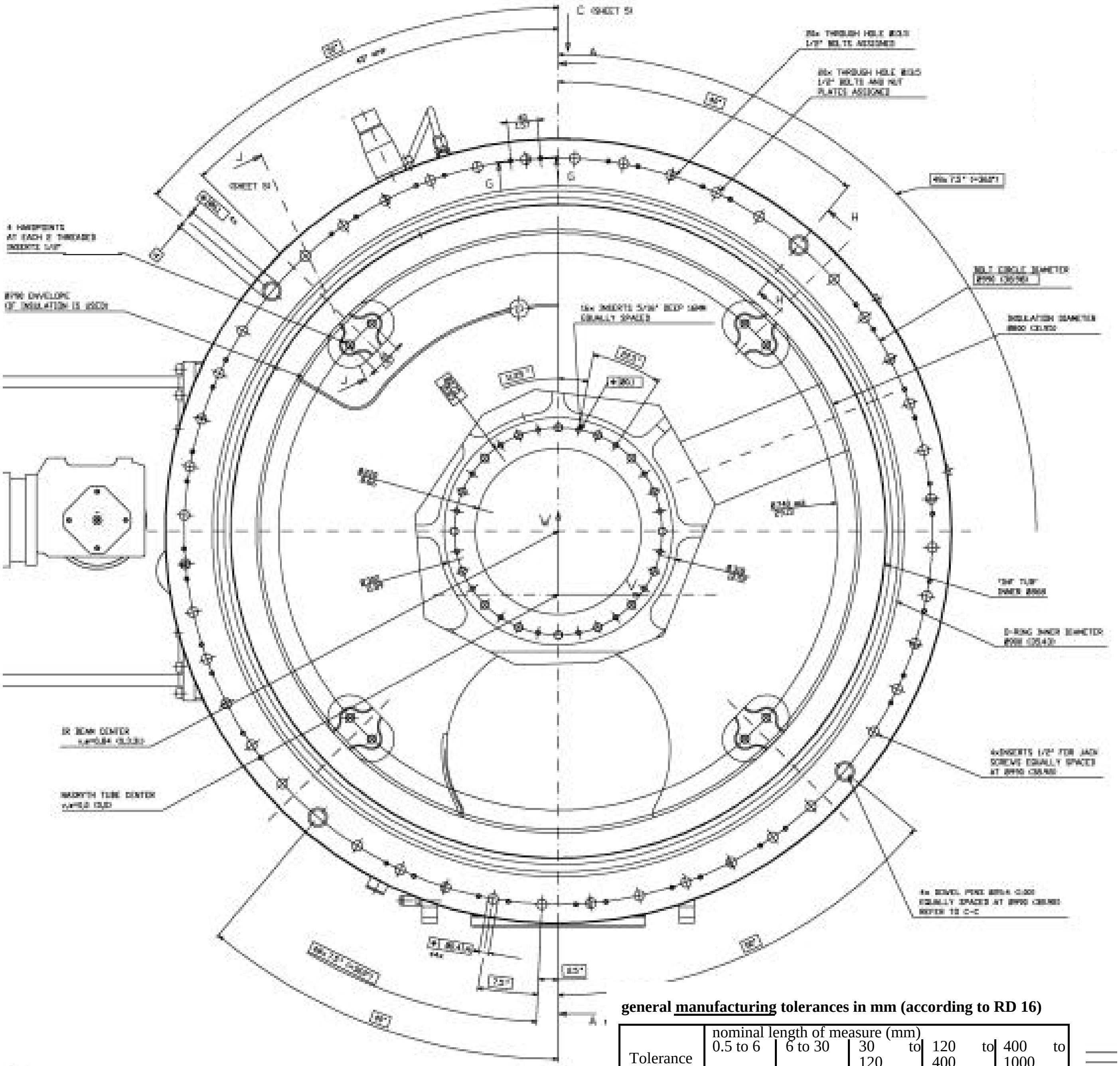


Figure 4-1: Front View of IMF (INF)
(refer to Appendix and RD11 for details)

general manufacturing tolerances in mm (according to RD 16)

Tolerance Class	nominal length of measure (mm) 0.5 to 6	6 to 30	30 to 120	120 to 400	400 to 1000
m (medium)	± 0.1	± 0.2	± 0.3	± 0.5	± 0.8

Note: as-built values will be given after manufacturing within a measurement protocol (refer to § 4.16)

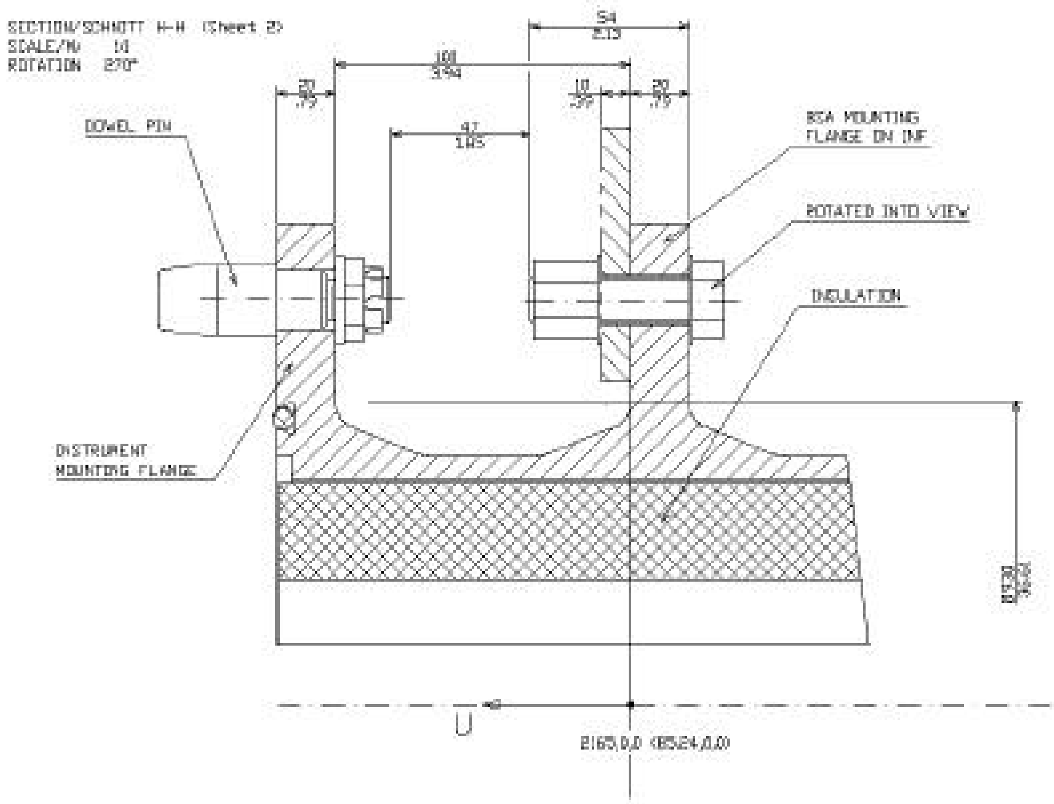


Figure 4-1b: Space between IMF back surface and BSA front Surface (from RD11) Dimension are given in mm (aove) and inches (below)

4.1.1 Position of Interface Plane

The interface plane between the SI Flange and the IMF is located in the U-constant plane of the TA coordinate system at

U = 2285 mm [U = 89.96 inch], perpendicular to the actual IR Beam Centerline within ± 20 arc-min.

The coordinate system is defined in RD3.

4.1.2 IMF Outer Diameter

The IMF has an outer diameter of

D_O = 41 inch [1041.4 mm]

The center of D_O is located at the TA Coordinates

W = 84 mm [3.31 inch]

V = 0 mm [0 inch]

4.1.3 Fixation Bolts

There are two bolt patterns for SI mounting purposes on the IMF. Each of them consists of 20 through holes. One pattern has fixation provisions for nutplates. When either bolt pattern is used washers will be installed under bolt heads.

4.1.3.1 Bolt Circle Diameter

The bolt circle is concentric with the IMF outer diameter (D_O); it has a diameter of:

D_B = 38.976 inch [990 mm]

4.1.3.2 Bolt Diameter and Thread

From strength calculations the bolt diameter has to be ≥ 12 mm [0.472 inch]

Bolts are sized to take axial accelerations during crash landings as specified in SOF-1030 for worst case SIs (600 kg) with all 20 bolts installed.

The bolts thread type is NAS (Anglo American), hence the bolt hole diameter allows also the use of metrical M12 bolts.

bolt thread diameter = 1/2 inch (1/2 – 20, NAS, _" diameter bolts)

4.1.3.3 Bolt Length

Bolt length = (TBD at the Critical Airworthiness Design Review CADR for each SI by the SI developer or USRA respectively)

Note: Information on bolt length not required by TA-C

4.1.3.4 Number of Bolts

Number of bolts = 20

4.1.3.5 Angular Spacing

The bolt hole pattern splits approximately the vertical, when the TA is at 40° elevation. The detailed angular spacing is given in figure 4-1.

4.1.3.6 Torque

The maximum installation torque on the bolt head will be 1,070 inch pounds [121 Nm].

4.1.3.7 Bolt Data

Modulus of elasticity E= 28 x 10^6 PSI

Yield tensile strength of bolts 1/2 - 20 = 22400 pounds

Ultimate tensile strength of bolts = 28800 pounds

4.1.3.8 Bolt Hole Diameter

The bolt hole diameter for both parts the IMF and the SI Flange is equal.

The through holes for the bolts have a diameter of 13.5 mm [0.5314 inch]

4.1.3.9 Nut Plates

One of the two bolt patterns has provisions for the attachment and removal of nut plates on the aft side of the IMF. For design details refer to Fig. 4-1 and RD11: SOF-DWG-KT-4000.0.01 sheet 5/5.

4.1.4 Dowel Pins

The dowel pins provide the accuracy and repeatability of the SI mounting on the IMF Flange. For SI mounting and positioning 2 of the 4 Pins are used. One of the dowel pins has to take the shear forces during crash landings and during extreme maneuvers (Telescope slamming into hard stops). The dowel pins are part of the IMF. The dowel pin design is depicted in figure 4-2. The two dowel pins not in use can be removed temporarily if desired or required by the current SI to be mounted.

Refer to RD18 for SI airworthiness certification procedures. Appendix 301-I of RD18 gives details on structural analysis for flange dowel pins and lugs.

The actual locations of the dowel pins after manufacturing were determined to be better than ±0.05 mm [± 0.002 inch] to their nominal locations as shown in Fig. 4-1 and Appendix.

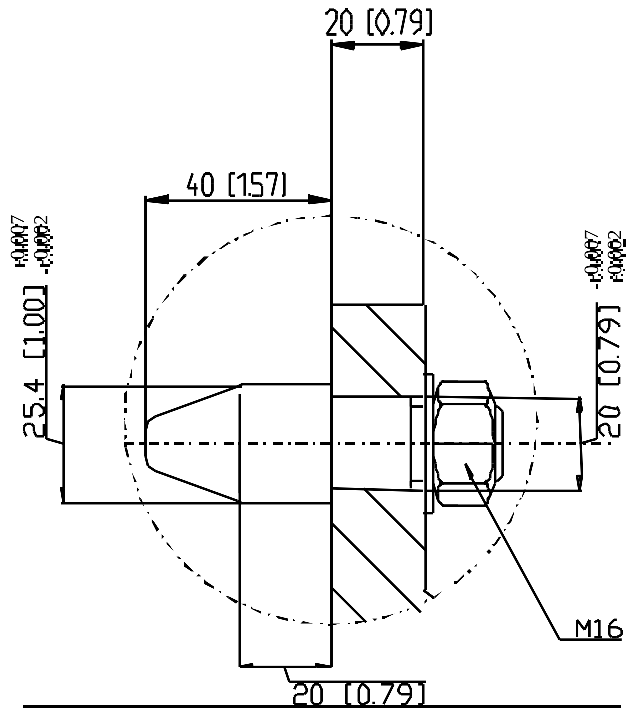


Fig 4-2: Dowel Pin Design (mm [inch])

4.1.4.1 Number of Pins

Total number of pins = 4
(2 each pattern)

4.1.4.2 Size

The dowel pin dimensions are given in figure 4-2.

4.1.4.3 Material

The dowels Pins are made from Stainless Steel DIN 1.4545 (hardened steel) with the following allowables:

Tension 253 KN

Shear Bearing 235 KN

Shear 186 KN

The allowables are ultimate values since there is no yielding for hardened steel material.

4.1.4.4 Shape

The dowel pin shape is given in figure 4-2.

4.1.4.5 Bore Hole (Pin) Diameter

Bore hole (pin) diameter on the TA Side is = 20 mm $^{+0.021}_{+0}$ [0.787 inch $^{+8E-04}_{+0}$]

Bore hole (pin) diameter on the SI Side is = 1 inch $^{+8E-04}_{+0}$ [25.4 mm $^{+0.021}_{+0}$]

4.1.4.6 Angular Spacing

dowel pin pattern is given in figure 4-1.

4.1.5 Jack Screws for Lift Off

The INF is equipped with 4 jack screws to lift off the SI from the INF. Locations of the jack screws are given in Fig. 4-1 or RD11.

Thread/Insert Specification: F8-15 (1/2-20) acc. to MS21209; Helicoil Fine Thread 1/2"x1.5D

4.1.6 Seal

The vacuum seal between the INF (IMF) and the SI is formed by an O-ring.

The O-ring is part of the INF. TA Consortium provides 1 O-Ring and 1 Spare.

The O-ring is held in a captive groove to avoid accidental removal.

The captive groove with the O-ring is shown in figure 4-3.

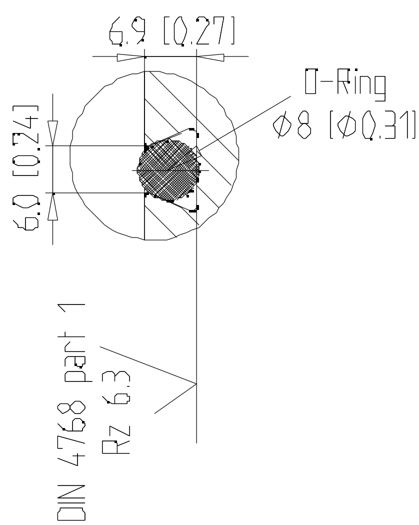


Figure 4-3: O-ring in captive groove (mm [inch])

4.1.6.1 O-Ring Diameter

O-ring diameter (inner dia.) = 900 mm [35.433 inch], centered on the IR beam (refer to figure 4-1).

4.1.6.2 O-Ring Material

The O-ring is made out of VITON or similar material

4.1.6.3 O-Ring Thickness

O-ring thickness = 8 mm [0.315 inch]

4.1.6.4 Surface Roughness and Planarity

The SI Flange surface which mates with the O-ring shall meet the following requirements:

DIN 4768 Part 1, Rz 6.3

planarity < 0.1 mm [0.004 inch]

surface roughness (mean value)< 0.0063 mm [2.5 10^{-4} inch]

4.1.7 Inner Diameter of INF / IMF

The inner diameter of the INF "Tub" is centered on the IR beam optical axis (V = 0 mm [0 inch], W = 84 mm [3.307 inch]).

The INF inner diameter is D_I = 800 mm [D_I = 31.496 inch] with insulation and 868 mm [34.17 inch] without insulation.

The free volume between the SI Flange and the Pressure Window Subassembly is defined in section 4.8.

There is a step on the front side of the INF Tub with 5 mm depths and an outer diameter of

884 mm $^{+0.1\ \text{mm}}_{-0.5\ \text{mm}}$ [34.803 inch $^{+0.004\ \text{inch}}_{-0.02\ \text{inch}}$]

which can be used for centering purposes.

4.1.8 Orientation Marker

There is one orientation markers on each of the outer walls of the IMF and SI Flange ring (refer to figure 4-4).

The angular Position is horizontal at 40 ° telescope elevation.

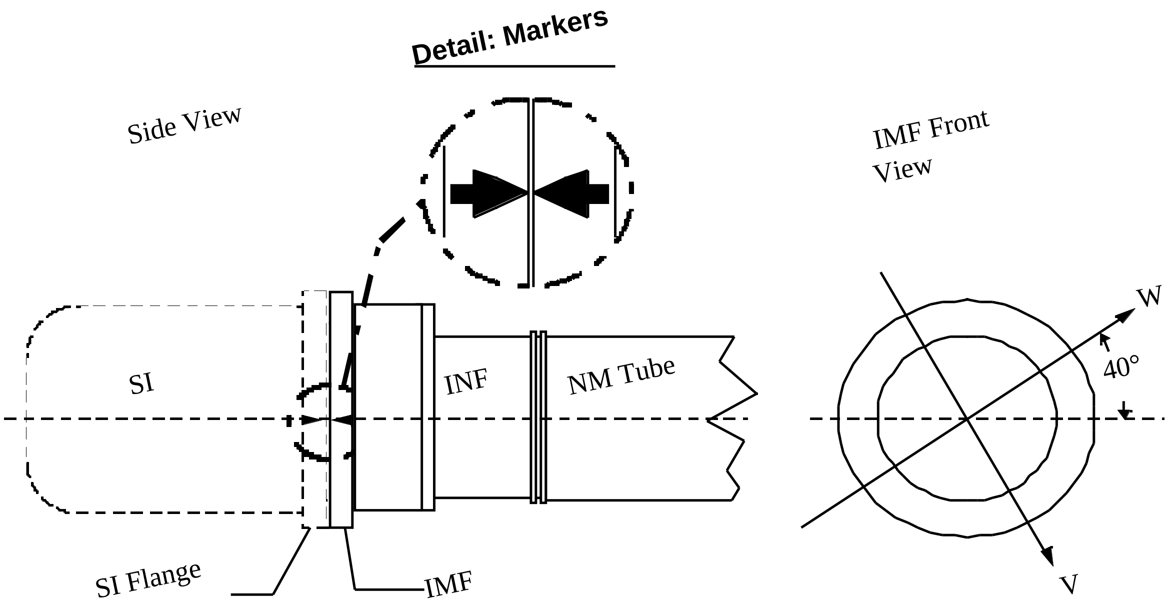


Figure 4-4: IMF and SI Flange Orientation Markers

4.1.9 INF Material

The INF is made out of stainless steel (DIN 1.4571, stainless chromium-nickel-steel with 0.05% C, 18% Cr, 10% Ni, 0.6% Nb, comparable to AISI 347, resp. ASTMA 240 316 TI)

4.2 Mass and C.G. of the SI

Due to the numerous different possible configurations of science instruments, mass and center of gravity are variable. C.G. and mass range of the SI are specified in RD19 and 20.

4.2.1 SI Mass and C.G. Range (static)

SI c.g. location (refer to RD19 for details):

longitudinal: (U coordinate axis direction) from U = 3285 mm [129.33 inch]

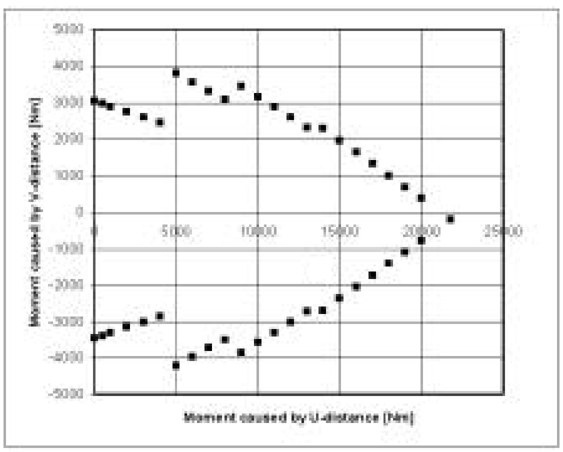
forward to U = 1785 mm [70.28 inch]

radial: within a cone shaped moment envelope defined by connecting adjacent points with straight lines in Figures 4.2.1-1 and 4.2.1-2. The shape of the envelope is influenced by the mass of the SI electronic rack located on the balancing subassembly of the TA.

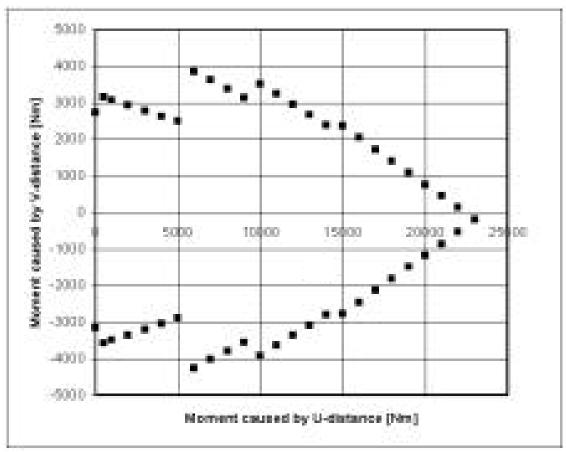
Two envelopes are given:

- considering a mass of the SI-rack of 150 kg (normal condition)
- considering a mass of the SI-rack of 100 kg (heavy Science Instruments, that will not fit within the normal envelope)

Figure 4.2.1-1 shows the maximum moments caused by cg-variation in V-direction
Figure 4.2.1-2 shows the maximum moments caused by cg-variation in W-direction.
The SI envelope is defined by a cone shaped by these axes.

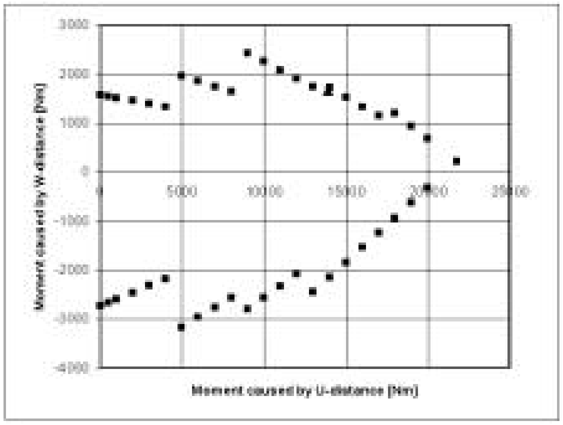


mass of SI-rack = 150 kg

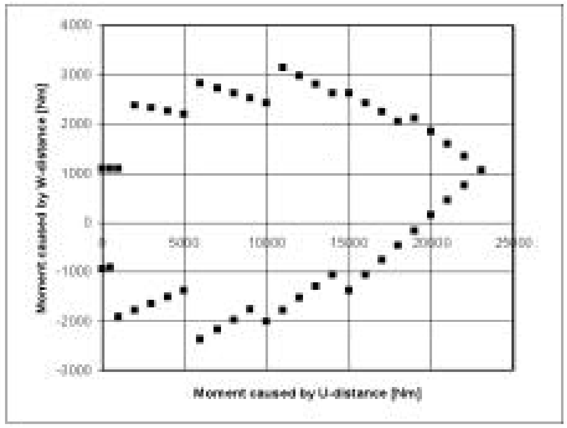


mass of SI-rack = 100 kg

Fig. 4.2.1-1



mass of SI-rack = 150 kg



mass of SI-rack = 100 kg

Fig. 4.2.1-2

4.2.2 Mass Change of SI During Flight

SIs which use cryogenics to cool their instrument change their mass during flight due to depletion of the cooling liquid in the dewar.

The TA provides its pointing accuracy and stability, without rebalance, under moment changes up to 150 Nm around XEL and LOS and 30 Nm around EL, caused by changes in SI mass and SI c.g. during flight.

The active balance subsystem is designed to accommodate SI mass and SI c.g. changes totaling an equivalent 800 Nm moment change around XEL and LOS and 400 Nm around EL calculated for a 10-hour flight.

4.3 Pressure Coupler Interface

The pressure coupler connects the open (optical) port of the Pressure Window Subassembly with Science Instruments which use only or additionally a small vacuum sealing interface diameter at the GVPP. The pressure coupler is provided by the SI developer if required. Within this document the interface of the coupler to the TA is described.

The pressure coupler shares the same interface to the TA as the Optical Window Assembly (refer to section 4.4). The pressure coupler / optical window interface is depicted in figure 4-7a

4.3.1 Configurations

There are various pressure coupler configurations. Some of them have additional connections to the vacuum and/or the exhaust fittings / feedthroughs of the tub (located as described in section 4.5 and 4-6) The configurations of the pressure coupler interface are shown in figure 4-5.

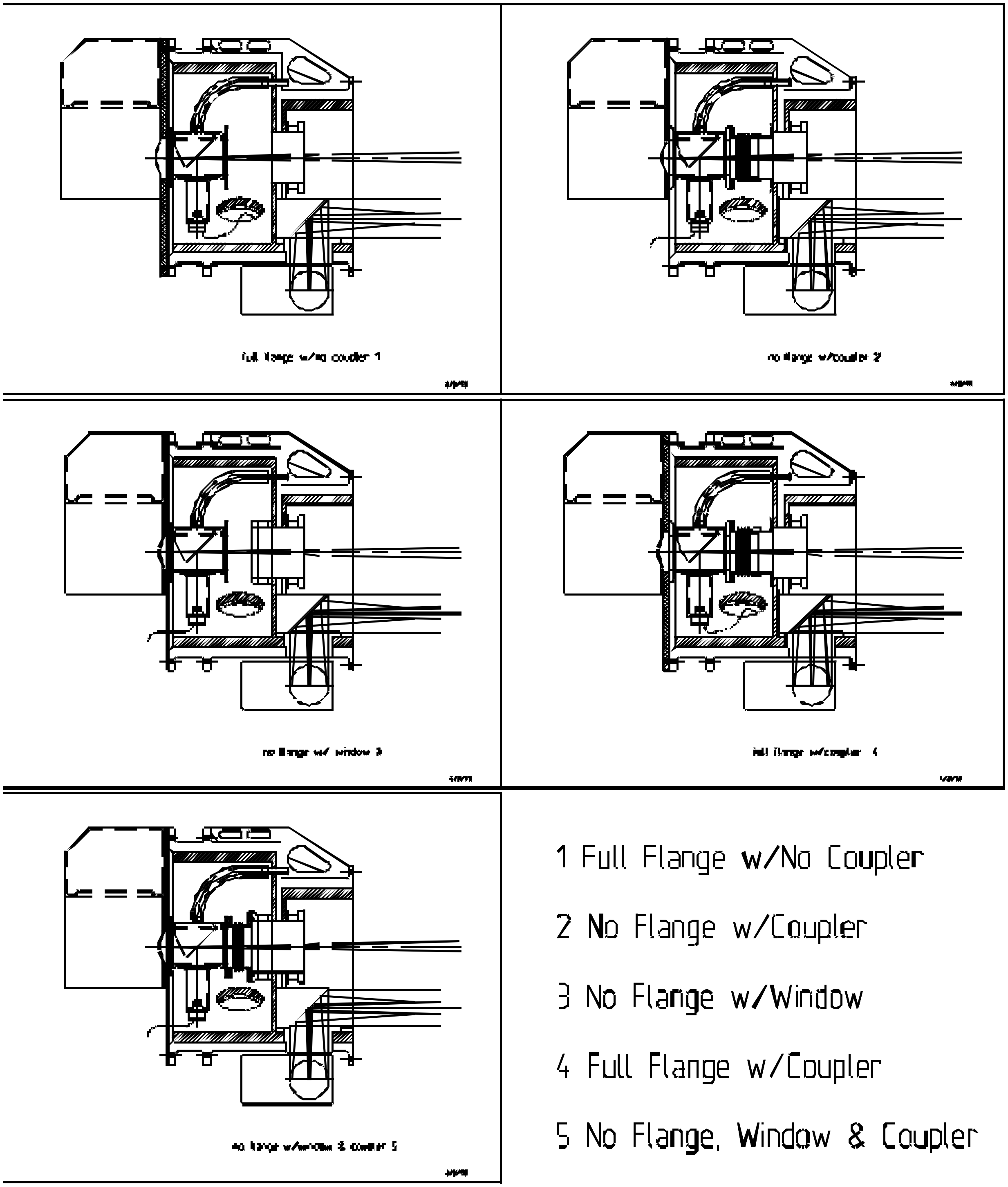


Figure 4-5: Pressure Coupler Interface Configurations (Not to scale, access port drawn into view)

4.3.2 Free Diameter

The free optical diameter of the pressure coupler interface is centered on the IR beam

(V= 0 mm; W = 84 mm [3.31 inch])

Free Diameter = 220 mm [8.66 inch] at U = 1800 mm [70.87 inch]

The vignetting is limited at U=1795 mm [70.67 inch] with a diameter of 220 mm [8.66 inch]

4.3.3 Position of Interface Plane

The interface plane of the pressure coupler to the TA is at

U = 1800 mm [70.87 inch]

4.3.4 Mechanical Interface Flange Diameter

The maximum mechanical interface flange (outer) diameter of the pressure coupler on the aft end = 300 mm [11.81 inch]

4.3.5 Fixation Threads

There will be threaded inserts at the interface for fixing the pressure coupler / optical window on the GVPP.

4.3.5.1 Insert Type

- 5/16 helical coil inserts,
- screw- locking 5/16-24 according to MS 21209
- Material CRES (corrosion resistant stainless steel)
- Dash No. F5 – 20
- Fine thread

4.3.5.2 Thread Size

Thread diameter x depth = 5/16 inch x 0.63 inch [7.9 mm x 16 mm] (refer to fig. 4-7a)

4.3.5.3 Number of Bolts

Number of bolts = 16**,** equally spaced in angular direction (refer to fig. 4-7a)

4.3.5.4 Bolt Circle Diameter

Bolt circle diameter = 275 mm [10.83 inch] centered on IR beam (refer to fig. 4-7a)

4.3.6 Pressure Seal

The pressure seal between the pressure coupler and the TA is given by an O-ring

The O-ring is part of the pressure coupler and is provided by USRA.

4.3.6.1 O-Ring Diameter

The O-ring inner diameter is centered on the IR beam. Various O-ring diameters are possible. The range for the O-Ring diameter is given below

O- ring inner diameter range = 230 mm [9.06 inch] < D < 240 mm [9.449 inch]

4.3.6.2 O-Ring Thickness

O-ring thickness < 6 mm [0.236 inch]

4.3.6.3 Surface Properties

Surfaces which mate with the O-Ring shall have the following properties:

DIN 4768 Part 1, Rz 6.3

planarity < 0.1 mm [0.004 inch]
surface roughness (mean value)< 0.0063 mm [2.5 10^{-4} inch]

4.3.7 Free Volume (Envelope)

The pressure coupler /optical window interface is countersunk in the GVPP. Thus, the stay-in envelope for the pressure coupler is limited to 300 mm [11.81 inch] between U = 1800 mm [70.87 inch] and U = 1885 mm [74.21 inch].

4.3.8 GVPP Motion under Pressure

The differential pressure between the fwd GVPP volume and aft GVPP volume causes the interface plane on the GVPP to move in the U-Direction. The motion is in the range of 0.1 mm [0.004 inch], resulting in a additional tilt of approximately 0.03 degrees. The pressure coupler has to accommodate these motions.

4.4 Optical Window Interface (Optical Window Assembly)

This interface equals the pressure coupler interface (section 4.3).

The design described here is compliant with DCR 0015.R2 (AD 04)

This interface does not include optical parameters like transmission, surface quality, index of refraction etc.

The change of focus position and a degradation of the image quality due to refractive, chromatical or other influences of the window is not reflected in this ICD.

The window element together with the window mount and the fixation ring forms an assembly, the Optical Window Assembly. The Optical Window Assembly is provided by USRA.

Relevant for the interface between SI and TA is only the mechanical interface between the Optical Window Assembly (i.e. the window mount) and the Flange Assembly (i.e. the GVPP).

The Optical Window Assembly design has to be capable to take loads, caused by motions of the GVPP under changing pressures (refer to section 4.3.8.for details).

4.4.1 Configuration

The Optical Window Assembly is depicted as concept in figure 4-7 b. It shows a possible mounting of the IR window element. This assembly will be mounted to the FA GVPP on the same interface as the pressure coupler, thus on the FA side there is only one interface.

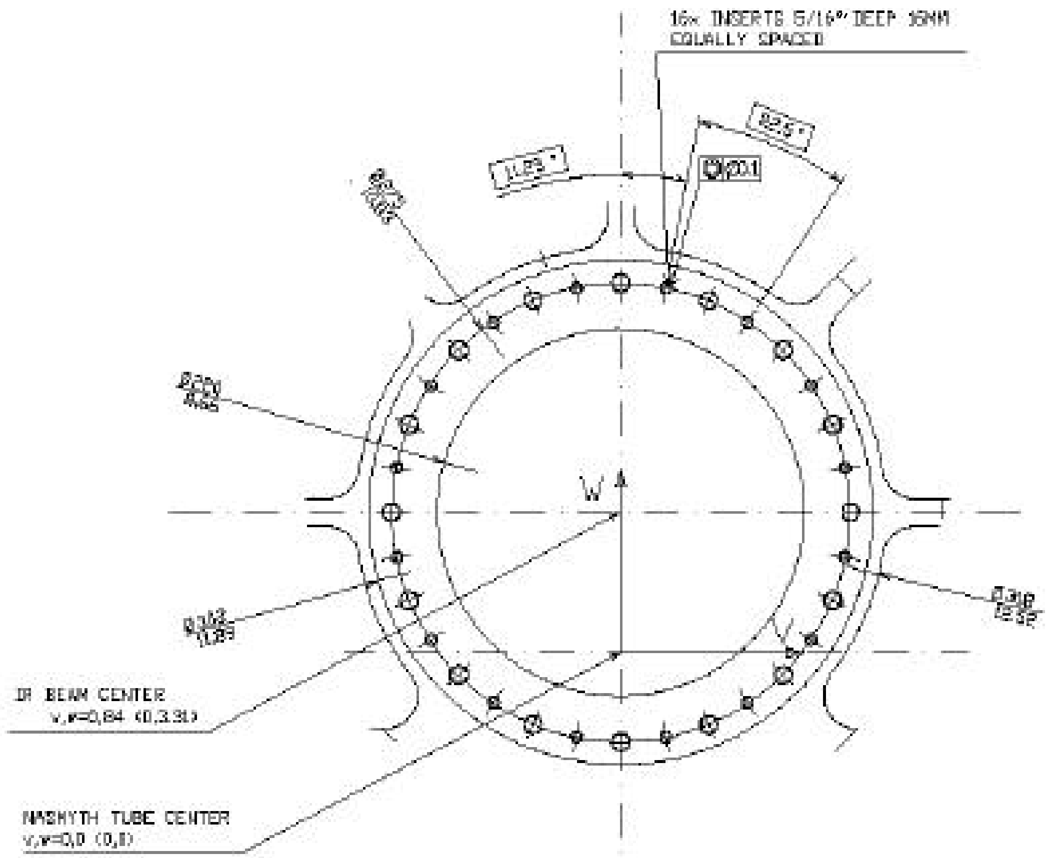


Figure 4-7 a: Pressure Coupler / Optical Window Assembly interface dimensions. Dimensions are given in mm (above) and inches (below)

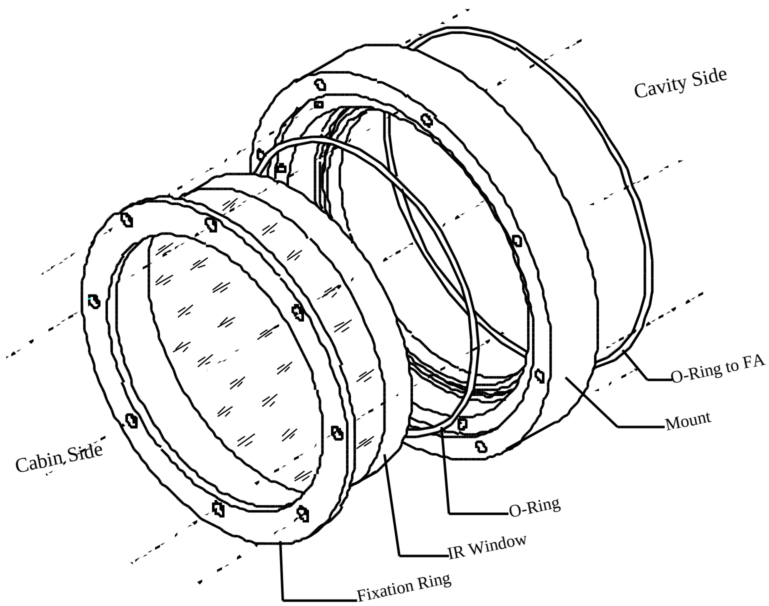


Figure 4-7 b: Example for a possible concept of Optical Window Mounting Assembly

4.4.2 Optical Free Diameter

The optical free diameter of the window mount

free diameter = 220 mm [8.66 inch] at U=1800 mm [70.87 inch]

4.4.3 Mechanical Diameter of the Mount

The mechanical (outer) diameter shall be equal to the mechanical flange diameter of the pressure coupler (refer to section 4.3, < 300 mm)

4.4.4 Bolt Circle Diameter and Bolt Size

Bolt circle diameter, bolt size and bolt pattern equal the dimensions of the pressure coupler interface (section 4-3, figure 4-7 a).

4.4.5 Seal Between Optical Window Assembly and TA/FA

The seal between the Optical Window Assembly and the Flange Assembly is carried out in the same way as for the pressure coupler (section 4-3).

The O-ring is part of the Optical Window Assembly and is provided by USRA.

4.4.6 Limit Loads for Pressure Coupler / Pressure Window Fixture

The pressure coupler/pressure window fixture is certified to take the loads given in section 4.9.1 for masses of 10 kg or less. Larger masses may have to be supported by other means as well as by the window fixture. Fixation configuration of larger masses than 10 kg is TBD by each SI critical airworthiness design review (Note: This information is not required by the TA-C).

4.5 Exhaust Tube Interface

The exhaust tube is routed from the fuselage via the Cable Load Alleviator and on the outside of the Flange Assembly to the SI or the INF Tub (refer also to ICDs TA_AS_11 and TA_SI_01).

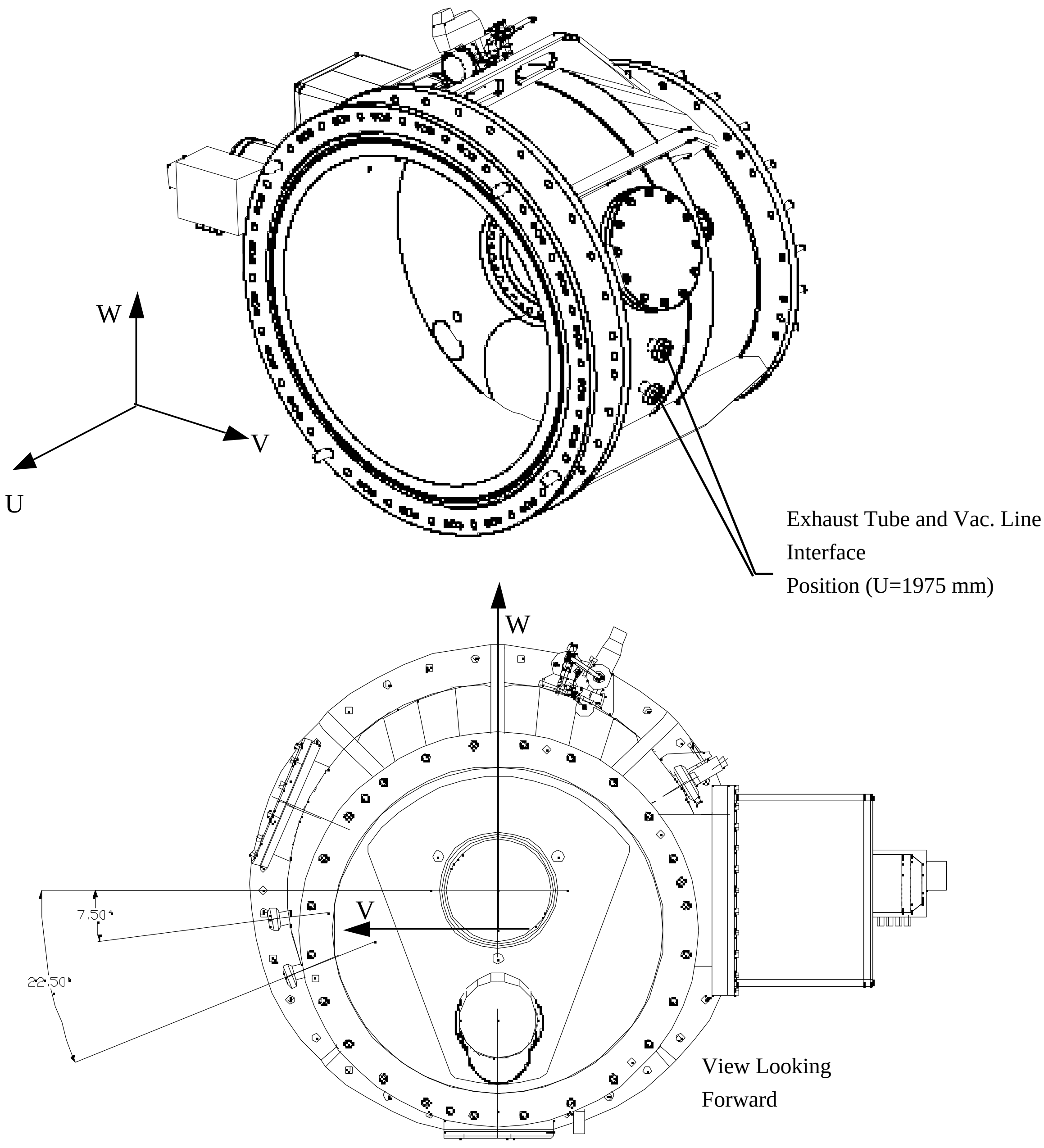


Figure 4-8: Position of exhaust tube and vacuum line connection

4.5.1 Tube Diameter

Refer to TA_SI_01 (RD21) and TA_AS_03 (RD22)

4.5.2 Tube Material

Refer to TA_SI_01 (RD21) and TA_AS_03 (RD22)

4.5.3 Type of Connection

On the cabin side of the INF there are two KF-25 Quick Flanges. The connection on the FA side can be used either for exhaust tube or vacuum line connection (refer to section 4-6).

On the KF-Connections standard hinged clamps and centering rings are used for fixation and sealing.

On the INF tube inner side there are 1 inch [25.4 mm] NPT threads for connecting for example a pump-out line to the pressure coupler. The NPT threads are closed by a piece of insulation when not in use. Thermal bridging should be avoided.

An additional interface can be used to connect to the volume between the Gate valve and the optical window. There is a T-Coupler in the tubing of the by pass valve, which connects this volume via the by-pass valve to the cavity. Type of Coupler is a 6 ECR 6 A-Lock fitting from Parker Hanninfin Corporation, suitable for 6 mm [0.236 inch] diameter tubes (nut size is 7/16 – 20 UNF).

4.5.4 Position of Connection

The exhaust tube / vacuum line connections on the cabin side of the INF are located radially on the INF tub (refer to figure 4-8).

Science Instrument or INF Tub will connect to the CLA via hoses (refer to RD 21).

The hoses do not require attachment points on the TA Flange Assembly structure.

Routing of the hoses is not part of this document.

4.5.5 Exhaust Blower Rate

Refer to section 4.7.3

4.6 Vacuum Lines Interface

The vacuum lines are routed from the fuselage via the Cable Load Alleviator and along the outside wall of the Flange Assembly to the SI or the INF Tub. This is described in various ICDs (RD 22: TA_AS_03, RD25: TA_AS_11; RD21: TA_SI_01). This ICD includes only the connection between the vacuum lines and the INF Tub. On the INF Tub there are two KF 25 connections which can be used either for vaccum lines or for exhaust tubes (refer to chapter 4.5).

4.6.1 Diameter

refer to TA_SI_01 (RD21) and TA_AS_03 (RD22)

4.6.2 Material

refer to TA_SI_01 (RD21) and TA_AS_03 (RD22)

4.6.3 Type of Connection

Refer to section 4.5.3

4.6.4 Position of Connection

Refer to section 4.5.4

4.6.5 Number of Lines

Refer to RD21

4.7 Thermal Interface

The volume fwd of the PWS (i.e.the INF Tub) is thermally insulated, but not thermally controlled. The surface temperature limits of the walls surrounding this volume are not specified. For PI purposes this volume shall be as large as possible. Due to the above given constraints the thickness of the thermal insulation will be kept at a minimum (i.e. will be dimensioned according to the heat transfer requirement given in SOF-1011 §3.3.2.5 only).

4.7.1 Heat Dissipation Requirements

To limit seeing effects and heating of the NT, the heat dissipation from the SI to the TA inner volume shall be kept as small as possible.

4.7.1.1 Electronics Heating

- Maximum heat by SI electronics mounted on the FA conducted to the FA ≤ **8 W**.
- Minimum heat input to the FA from SI electronics is **0 W**.

4.7.1.2 Convective Heating

Heating of the SIs will occur due to convective contact between the SI and the cabin air. Cooling of SIs will be primarily through conduction to the FA. The heat input to the FA can only be calculated with the thermal model of the FA, because it depends on the equilibrium temperature of the FA. The following are inputs for the FA/TA thermal model:

- Maximum heat input:

  This would correspond to an SI with maximum surface area mounted with negligible thermal impedance to the FA. This maximum surface area is roughly that of a cylinder with 1 m [39.37 inch] diameter and 2 m [78.74 inch] length with only one end not exposed to cabin air, or 7.5 m^2 [11.62 inch_] exposed to the cabin. The SI seals at the SI flange, and an insulation of the same quality as on the interior of the FA tub is used on the aft side of the SI mounting plate. For this case the gate valve is assumed to be open, and no window is used. The thermal conductance between the SI and the FA is about 300 mW/K.

- Minimum heat input:

  This would correspond to an SI with minimum surface area mounted with insulation between it and the FA. The minimum area might correspond to a cylinder 25 cm [9.84 inch] in diameter and 25 cm [9.84 inch] high. The insulation can be modeled as a 6 mm [0.236 inch] thick, 25 mm [0.984 inch] wide, and 100 mm [3.937 inch] diameter G10 fiberglass ring. Such a small SI can be assumed to be mounted on the gate valve with a short, 10 cm [3.937 inch] diameter pressure coupler, and to have most of its surface insulated with insulation of the same quality as the interior of the FA tub. The SI area is about 0.3 m_ [465 inch_] and thermal conductance between the SI and the FA is about 30 mW/K.

4.7.1.3 Radiative Heating

Radiative effects are estimated with the following simple assumptions:

- The power radiated from the SI mounted on the IMF flange into a 25 cm [9.84 inch] diameter hole located at the gate valve is between **2W and 13 W**
- A power of **2 W** is radiated from the 10 cm [3.937 inch] diameter mounting flange into the Nasmyth Tube through the hole in the gate valve.

4.7.2 Interface Temperature Limits

The temperature limits for the TA to SI shall be kept as low as possible in order to keep the N2 consumption, the dimensioning of the cooling fans and blowers as small as possible.

In the moment the SI interface temperatures are considered to be 300 K.

Interface temperature limit ≤ 300 K

4.7.3 Airflow through exhaust line(s)

Airflow rate in the tub (through exhaust line(s)) is large enough (i.e. ≥ 20 cfm) to avoid backflow into the Nasmyth Tube when the Gate Valve is open without a window installed. This is required for proper operation of the Nasmyth tube cooling system and to meet the SOF-1011 surface temperature requirement.

4.7.4 Operation and Environment

To avoid ice forming on optical elements, sensors and mechanisms which would reduce performance, functionality and lifetime of above items, all operations must guarantee, that no moist air is in the tub when pressure will be equalized before opening of the Gate Valve. This can be assured by pumping out the tub or a pressure coupler, using the vacuum pump connection before the Gate Valve is opened.

4.8 Free Volume Aft of the SI Flange

Although there is no requirement, there will be a free volume available inside of the FA between the Pressure Window Subassembly and the Instrument Mounting Flange. This volume might be used by the PI or the operator for different purposes such as a boresight box, small SIs which do not follow the SI envelope requirement and others.

The free volume is given by a cylinder centered on the IR Beam optical axis (V, W) = (0 mm, 84 mm) [(0 inch,3.307 inch)].

Mechanical cylinder diameter = 800 mm [31.5 inch] with insulation and 868 mm [34.17 inch] with the insulation removed. INF Tub side wall insulation is removable. A margin of 10 mm [0.394 inch] between stay-in and stay-out envelope should be used.

SI stay-in envelope with insulation = 790 mm [31.1 inch] x 390 mm [15.354 inch]

SI stay-in envelope with insulation removed = 825 mm [32.48 inch] x 390 mm [15.354 inch]

Fwd end of envelope cylinder is at the SI interface plane (U= 2285 mm [89.961 inch] refer to section 4.1.1)

Aft end of envelope cylinder is at U = 1895 mm [74.606 inch].

4.9 Worst Case Loading Imparted to the SI by the TA

The worst case loading imparted to the SI by the TA under operational flight conditions are defined in this chapter. During flight operation, the aircraft vibrations are attenuated by the VIS. The vibration levels at the SI Interface will be measured during vibration testing. This document gives only expected vibration level from mathematical simulation.

4.9.1 Acceleration at SI Interface

Total linear accelerations at the Science Instrument c.g., located at (c.g._U, c.g._V, c.g._W), can be calculated from numbers in Table 4-1 using the following matrix transformation:

$$\begin{vmatrix} AU \\ AV \\ AW \end{vmatrix} = \begin{vmatrix} US \\ VS \\ WS \end{vmatrix} + \begin{vmatrix} 0 & a\_rot\_w & a\_rot\_v \\ a\_rot\_w & 0 & a\_rot\_u \\ a\_rot\_v & a\_rot\_u & 0 \end{vmatrix} \begin{vmatrix} c.g.\_U \\ c.g.\_V \\ c.g.\_W \end{vmatrix}$$

Notes:

- TA-Coord. System and Aircraft-Coord. System are according to SOFIA Coordinate Systems ICD Global_05
- Resulting Loads at the SI Flange are dependent on the respective SI mass, SI c.g. and SI moments of inertia
- All tables are basically compiled from Design Loads SOF-TAN-MG-0000.0.04 Issue 04 Date 17.11.99 (RD12)
- The reduced number of load cases presented in this notice does not release each SI stress analyst from the verification of all applicable loads on his own responsibility.
- For details refer to the design load document RD12, Section 6.9.
- The temperature load cases are only applicable for parts which are not influenced by the cabin-cavity gradient or other thermal sources. For inhomogeneous temperature distributions additional load cases must be defined by each stress analyst.

Load cases are only listed for verification of structural strength, not for function of mechanical components.

Aircraft flight, TA operating, uncaged								
Flight Cases	Linear Acceleration at (U,V,W)=(0,0,0) (g (= 9.8 m/ s^2))				Rotational Acceleration about (U,V,W) = (0,0,0) (rad/s^2)			Pressure Diff. (bar)
	US	VS	WS		a_rot_u	a_rot_v	a_rot_w	PRUC
RRBPT2b	0	-1,0	0		16,69	0	3,32	0,65
RLCPT2b		-1,0			-16,69		-3,32	0,65
PVCPT2b		-2,9			-2,12		-2,83	0,65
PVBPT2b		-2,9			-0,16		-0,21	0,65
PWBPT2b			2,9			-2,30		0,65
PWCPT2b			2,9			-0,17		0,65
YRVCPT2b			1,0		-2,45		-3,28	0,65
YLVBPT2b			1,0		2,45		3,28	0,65
YRWCPT2b		-1,0				2,66		0,65
YLWBPT2b		-1,0				-2,66		0,65
SVBPT2b		-1,0			-0.60		-0,80	0,65
SWCPT2b			1,0			0,65		0,65

Table 4-1 : TA Flight Operation Cases resulting in extreme accelerations. Cases are defined in RD 12 and included TA in varying elevation positions and under varying disturbances. The pressure difference is between cabin and cavity.

Scaled case	Basic case linear acceleration			press.
	US	VS	WS	PRUC
Aircraft flight, TA caged				
LUVAPT3b	+1,0	-1,0		0,65
LUWAPT3b	+1,0		+1,0	0,65
LVPT3b		-3,29		0,65
LWPT3b			+3,29	0,65
UVCPPT3b	-0,81	-2,37		0,65
UWCPPT3b	-0,81		+2,37	0,65
LUVFMT3b	-1,07	-1,0		-0,017
LUWFMT3b	-1,07		+1,0	-0,017
LWXT3b			+1,0	0,86

Table 4-2 Structure relevant flight cases (ref. to RD12)

Scaled case	Basic case linear accel.		
	US	VS	WS
Aircraft on ground incl. taxiing and towing			
LUVFT3a	-1,07	-1	
LUWFT3a	-1,07		+1
LVT3a		-3,29	
LWT3a			3,29
SVTxa		-1	
SWTxa			+1
SVTxab		-1	
SWTxab			+1

Table 4-3 Structure relevant ground cases (ref. to RD12)

Scaled case	Basic case linear acceleration US	VS	WS
Aircraft flight, TA caged, Emergancy Landing			
UEM	-9		
VEM		-6	
WEM			+6
Aircraft flight, TA uncaged / caged			
UOC	1		
VOC		1	
WOC			1
Handling loads			
UHA VHA WHA	Analyse separately due to different boundary condition		

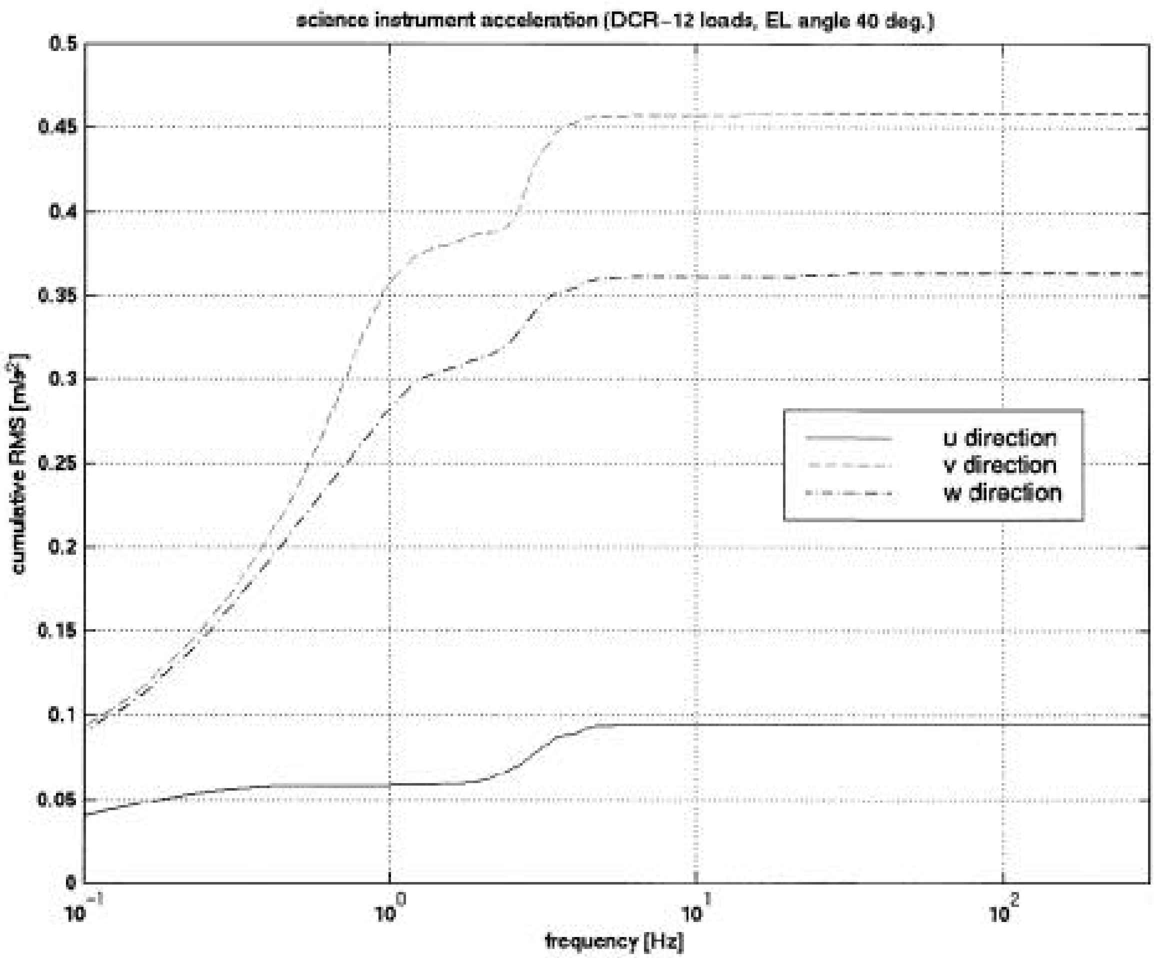
Table 4-4 Single cases (ref. to RD12)

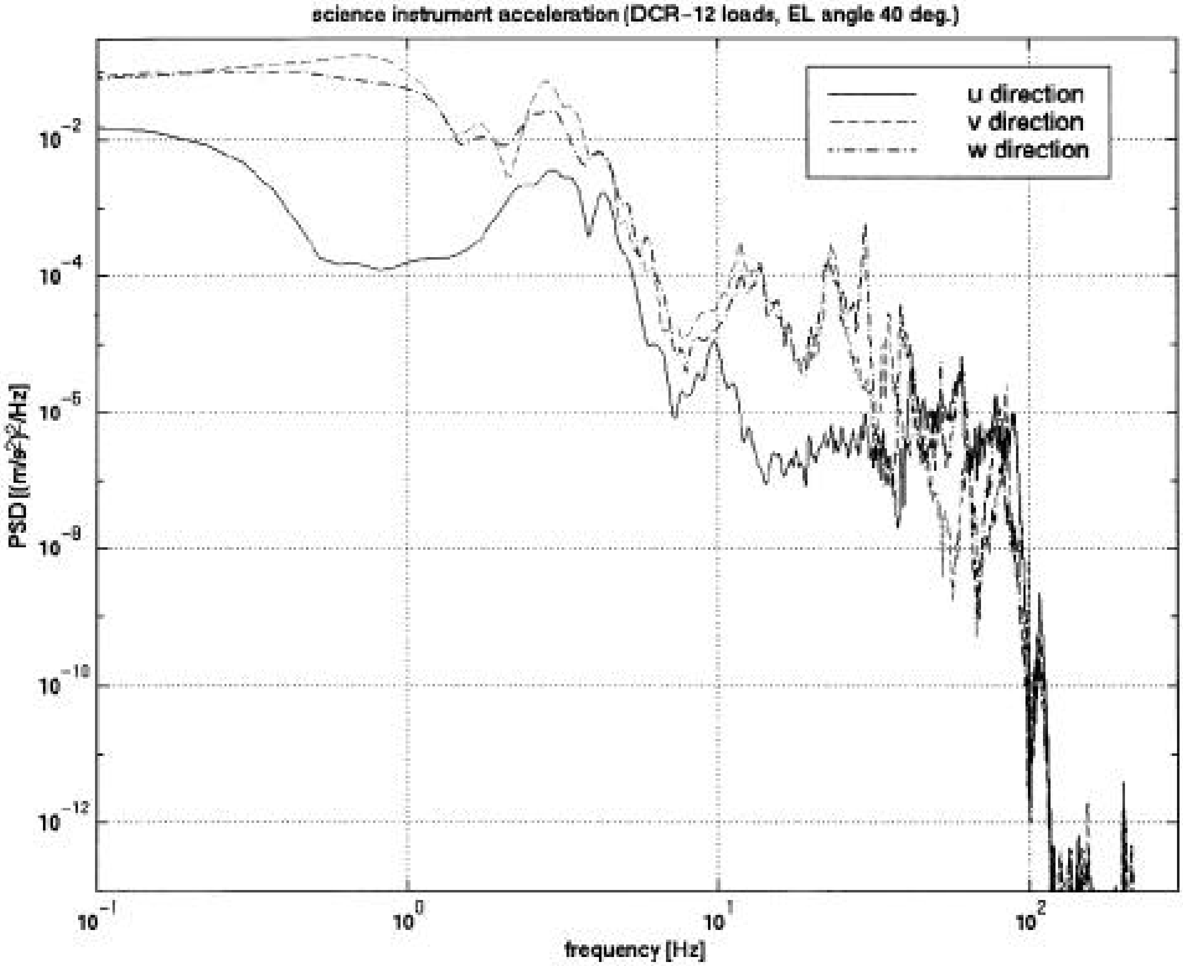
Case	Cabin Temperature [°C] Absolute	Difference to 22,5°C
2b. TA flight		
T2b2	28	5,5
T2b4	12	-10,5
3a. towing and taxiing		
T3a2	55	32,5
T3a5	-10	-32,5
3b. aircraft flight		
T3b1	35	12,5
T3b5	5	-17,5
Exposure a. (Safety)		
TEXa2	85	62,5
TEXab5	-40	-62,5

Table 4-5 Temperature Cases for structural components in cabin (ref. to RD12)

4.9.2 Vibration

PSD curves from a preliminary analysis are given below. Final vibration levels will be available after TA Vibration Tests.





science instrument acceleration (DCR−12 loads, EL angle 40 deg.)
u direction
v direction
w direction
PSD [(m/s²)²/Hz]
frequency [Hz]

4.10 Hardpoints in the INF Tub

There are 4 hardpoints on the GVPP each with two _ inch fixation threads (Helicoil inserts 1/2” x L 1”), located on a diameter of 740 mm [29.13 inch] which is centered on the IR beam optical axis (refer to figure 4-1).

The hardpoints are located in U-Direction at U= 1840 mm [72.44 inch]

Note that the hardpoint interface plane lies behind the GVPP insulation (U= 1885 mm [74.213 inch]) and that the stiffener webs on the GVPP increase their height from GVPP edge (U= 1840 mm [72.441 inch]) to GVPP Center (U=1860 mm [73.228 inch]) refer to figure 4-9.

Insert specification (according to MS 21209):

- Insert: 1/2-20 F helical coil insert
- Depth: 1 inch [25.4 mm]
- Material: CRES
- Dash No.: F8-20

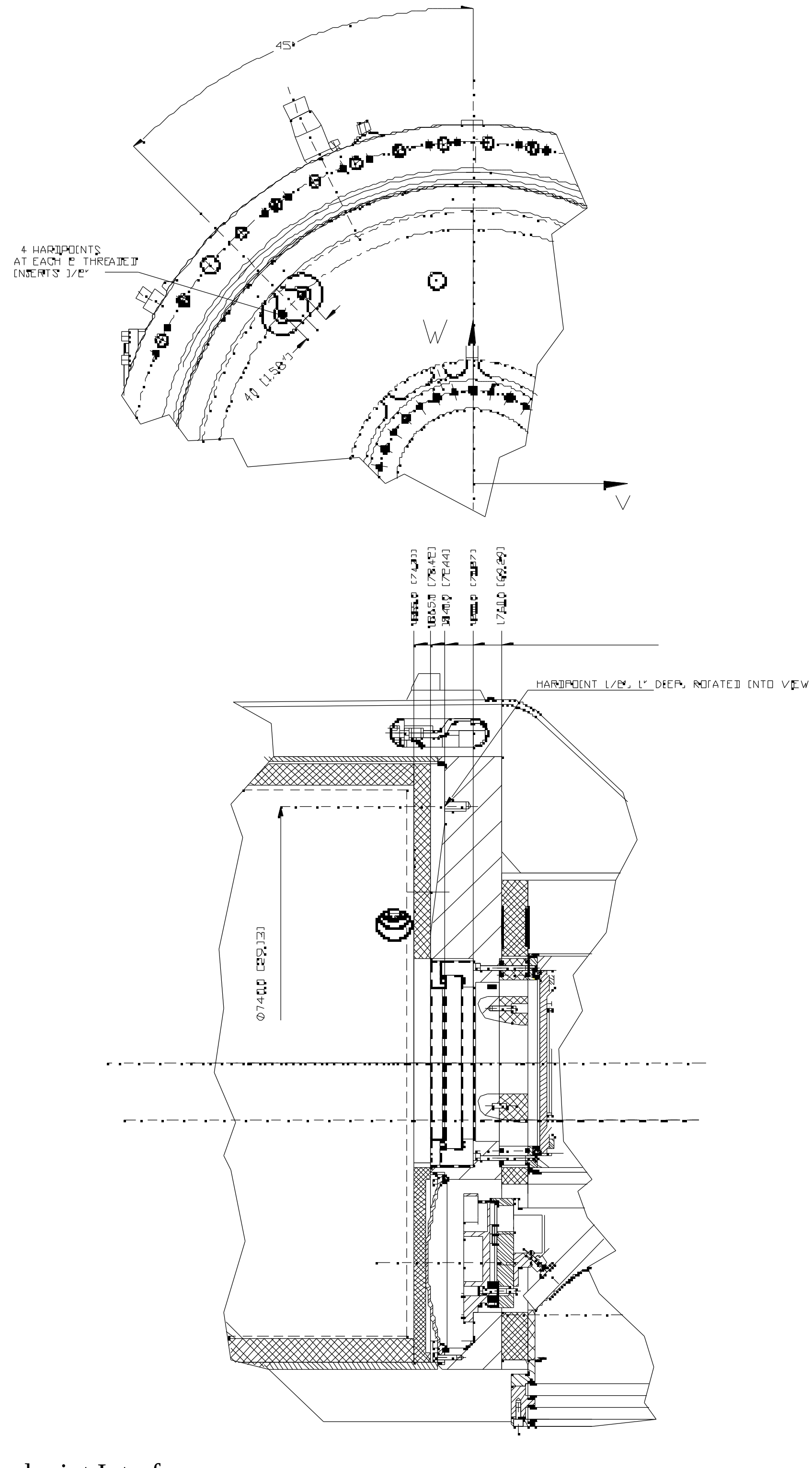


Figure 4-9: Hardpoint Interface

4.10.1 Loads

The single loads / moments on one hardpoint are given below and in figure 4-10. The loads were determined under the assumption, that always both screws on the hardpoints are used.

Ultimate Loads:

- The maximum allowed moments on each hardpoint are 60 Nm
- The maximum allowed axial forces are Fu = 1500 N on each hardpoint
- The maximum allowed radial forces are Fv,w = 1500 N on each hardpoint

Limit Loads:

- The maximum allowed moments on each hardpoint are 40 Nm
- The maximum allowed axial forces are Fu = 1000 N on each hardpoint
- The maximum allowed radial forces are Fv,w = 1000 N on each hardpoint

According DCR0012.R5 (AD5), there is a factor of 1.5 between limit and ultimate loads.

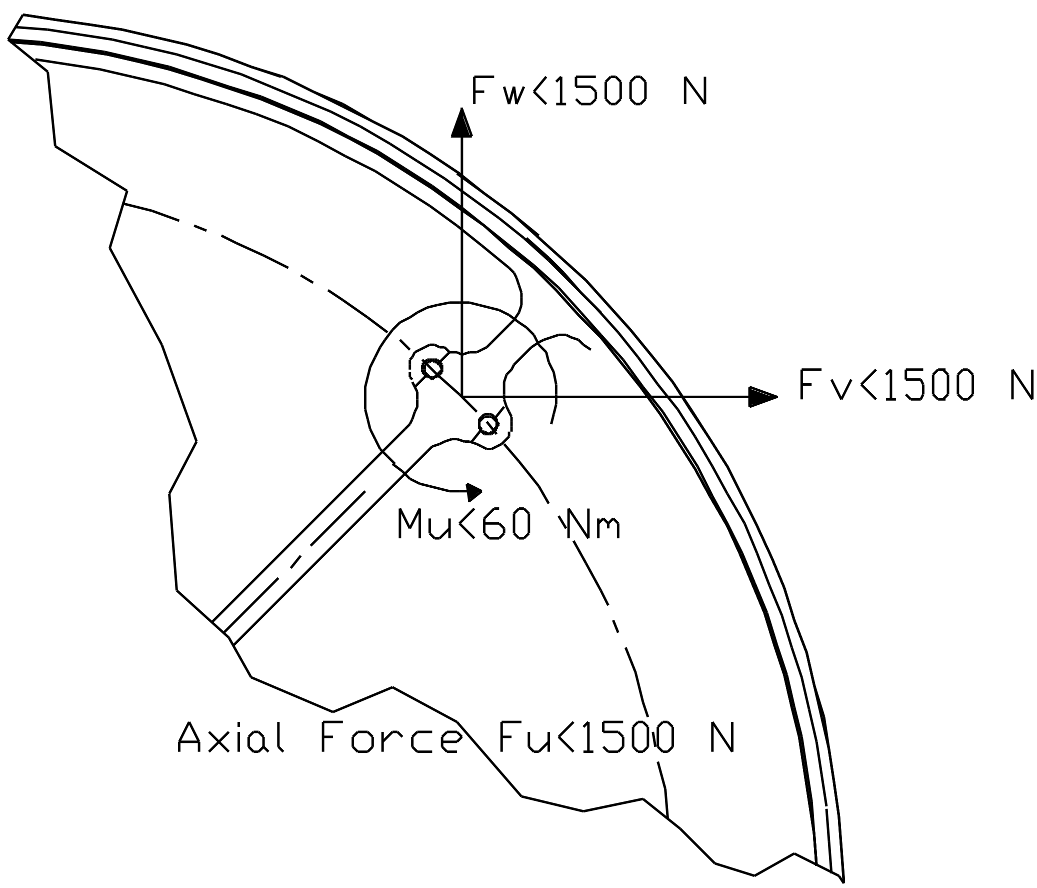


Figure 4-10: Maximum loads and moments on a hardpoints (ultimate)

4.10.2 Thermal Constraints

To avoid thermal bridging during standard operation (hard points not used), the hardpoints will be covered by a piece of thermal insulation.

Any heat load from SI hardware attached to the hardpoints will not be considered for the TA thermal design.

4.10.3 Stiffness and Tolerances

There is no possibility to provide a number for the stiffness of each hardpoint, since it is depending too much on the respective Item which is mounted to it (e.g. how many hardpoints are used, mass of item, c.g. and moment of inertia of item, stiffness of item)

Hard points are located to each other on a circle of 740 ± 0.3 mm [29.134 ± 0.012 inch]

4.11 Access Port

There is an access port located at U = 1975 mm [77.76 inch] on the INF Tub outer surface with an inner diameter of 8 inch. It is oriented in radial direction at angle VW= 22.5 °. The access port is not designed for attachment of additional hardware. The access port is the primary cabin to cavity pressure boundary under some SI configurations. The Access Port Cover Plate has insulation attached to avoid thermal leakage, and an O-ring pressure sealing. Size of O-ring: 216 mm x 5 mm.[8.504 inch x 0.197 inch].

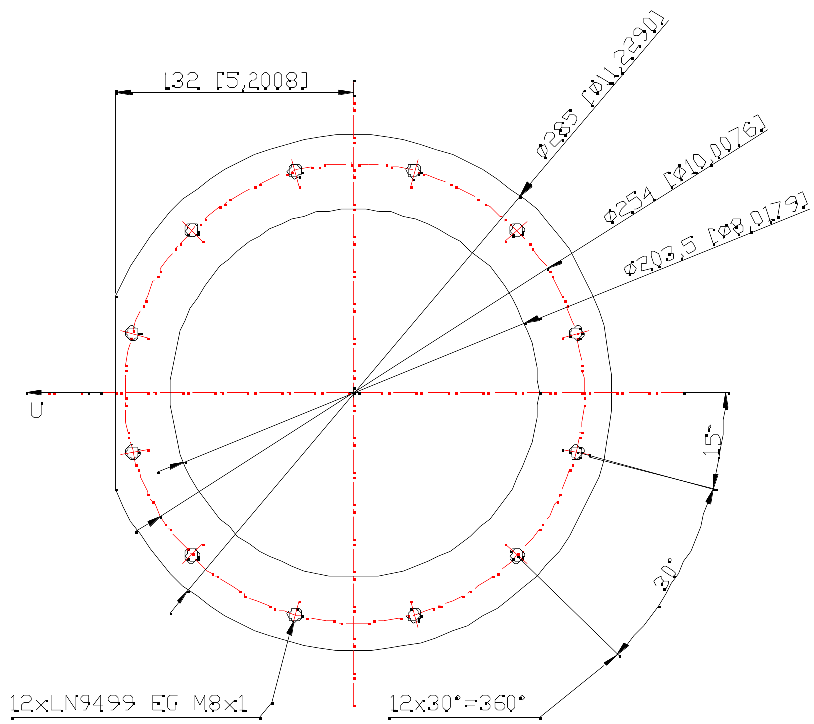


Figure 4-11: Accessport Bolt Pattern (12 threaded inserts with thread M8x1, 2D deep)

4.12 Mass Limit for Integration / Deintegration

NASA / USRA plan to remove the FA from the TA for different purposes. Due to aircraft floor loading restrictions the mass limit for one integration unit is 600 kg

4.13 Size Limit for Integration / Deintegration

NASA / USRA plan to remove the FA from the TA for different purposes. Due to aircraft restrictions the size limits for one integration unit are the 1 L Door dimensions as given in TA_AS_04 (RD23)

4.14 Nominal Electromagnetic Field at IMF

The electromagnetic field at IMF during operation is **to be measured during system AITV.** Refer to TA EMC Control Plan for details on TA EMC design (RD17).

4.15 Grounding of FA and TA

The grounding concept of the FA and the TA is described in RD9.

The contact resistance between metal parts shall be ≤ 0.25 Ω at the interface. If this cannot be achieved grounding straps / cables shall be used.

For SI grounding purposes there is a ground bolt on the FA with a diameter of 6mm [0.236 inch] with M6 thread (metric) and 25 mm [0.984 inch] length.

4.16 Flange Mockup Input Data and Policies

Inputs for the design and manufacturing of the USRA Flange Mockup will be provided by KT in the form of design drawings and as-built data. Drawings will be the actual specifications.

5 SRM & QA

5.1 Safety

Interface design information in this ICD is referenced in PD96165004-000 (PA10-002, The Observatory Hazard Analysis) for hazard mitigation design control for specific design features crossing the interface boundary as described in the scope of this document.

5.2 Quality Assurance Provisions

Quality Assurance will verify each hardware interface to the drawing, and participate in testing by reviewing and verifying plans and procedures; witnessing tests; and approving reports in accordance with PD96100021-000 (PM21), for the USRA side of the ICD, and SOF-PLA-MG-0000.0.03 Safety, Reliability, Maintainability and Quality Assurance (SRM & QA) Plan, for the TA-C side of the ICD, respectively.

5.3 Verification

The verification plan for this interface is documented in PD96157000-000 (PM12, SOFIA Observatory Integration, Test and Verification Plan), for the USRA side of the ICD, and in SOF-PLA-MG-0000.0.13 (SOFIA Telescope Assembly Verification Plan), for the TA-C side of the ICD, respectively.